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Date: August 22, 2004

By: 

David Bogart Dort

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IN RE APPLICATION OF: Cochrane, Paul Douglas

APPLICATION NO.: FILED HEREWITH

FILED: August 22, 2004

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For: REDUCING DAMAGING ROTATIONAL AND
EXTERNAL VIBRATIONS IN HIGH-SPEED
ROTATIONAL DEVICES USING ELASTICIZED
POLYMERIC STRUCTURES

**Transmittal of Utility Patent Application
for Filing Under 37 CFR §1.53(b)**

Mail Stop: New Application
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Box 1450
Alexandria, VA 22313-1450

Sir: Transmitted herewith for filing is a patent application by inventor(s): Paul Douglas Cochrane entitled:

**REDUCING DAMAGING ROTATIONAL AND EXTERNAL VIBRATIONS IN HIGH-SPEED
ROTATIONAL DEVICES USING ELASTICIZED POLYMERIC STRUCTURES**

1. Enclosed are:

- ☒ This Transmittal letter.
- ☒ One stamped, self-addressed postcard for PTO datestamp.
- ☒ Certificate of Express Mail. 37 CFR 1.10.
- ☒ One utility patent application containing text pages 1-28 and
- ☒ 13 Sheets of informal drawings.
- ☒ Unsigned Declaration and Power of Attorney

2. U.S. Priority:

This Application is a continuation of and claims priority under 35 USC §119(e) to co-pending US Provisional Application 60/554,364 filed March 19, 2004 entitled HARD DRIVE HAVEN, which is incorporated by reference herein.

3. Foreign Priority: None4. Fees

The filing fee has been calculated as shown below:

For:	(Col. 1) No. Filed	(Col. 2) No. Extra	Small Entity			Other Than a Small Entity	
			Rate	Fee		Rate	Fee
Basic Fee				\$385.00	or		\$770.00
Total Claims	37	178	x \$ 9 =	\$ 0 153	or	x \$ 18 =	\$
Independent Claims	4	10	x \$43 =	\$ 43	or	x \$ 84 =	\$
<input type="checkbox"/> Multiple Dependent Claim Presented			+ \$140 =	\$	or	+ \$280 =	\$
*If the difference in Col. 1 is less than zero, enter "0" in Col. 2.			TOTAL	\$	or	TOTAL	\$

- ☒ Applicant claims small entity status. See 37 CFR §1.27.
- ☒ **Please do not charge fees**, the Applicant will submit all required fees, along with a surcharge, upon submission of a response to an anticipated Notice of Missing Parts along with required papers.

Respectfully submitted,
DORT CLOSE IP LAW GROUP PLLC

Date: 8/22/07


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LIFE EXTENSION IN HARD DISK DRIVES THROUGH VIBRATION AND THERMAL DAMPENING USING POLYMER SPRINGS

Invented by Paul Douglas Cochrane, Discovery Bay, CA

REFERENCE TO PRIORITY DOCUMENTS

[0001.] The present application claims priority under 35 USC §119(e) to US Provisional Application Serial No. 60/554,364 entitled HARD DRIVE HAVEN and filed on March 19, 2004, which is hereby incorporated by reference for all purposes.

BACKGROUND

[0002.] During operation, the HDDs generate create vibration as they rotate. By definition, a hard drive system will undergo *rotational vibration* when an oscillating moment is applied. When a hard disk drive is idle, the oscillation can be caused by friction in the spindle bearings or by rotational imbalance of the platter(s). When the drive is under read/write or seek conditions, inertia forces from activity of the actuator arm can cause rotational vibration (RV) is characterized by **rad/s**, which is the rotational analog of linear acceleration **m/s²** or **g**. When HDDs are packaged in close proximity they can, and most often will, propagate RV from one drive to another degrading drive performance. The vibration can become excessive, particularly when adjacent HDDs are operated simultaneously. Moreover, as HDD technology progresses to faster rotational speeds and cost-reduction architectures, the vibration problems are exacerbated.

[0003.] In addition to the drive-to-drive induced vibration, there is also the real possibility of vibration being induced by the environment in which the drives are located. As an example of this would be in a data closet, where network storage

equipment is maintained, there could be a number of external sources that can induce vibration. An air conditioner in any relatively near location would be a specific example.

[0004.] Vibration can also come in the form of acoustic vibration or the HDDs can produce disturbing acoustic noise, particularly for the consumer product applications. As personal computer become more prevalent in the home and HDDs are being used for audio/video and entertainment applications, acoustic noise emissions are becoming important to consumers. Another factor in determine performance is acoustic noise by the HDD. For example, research has found that the leading question by consumers with respect to hard drives was *"How loud will this drive be in my system?"* The acoustic noise comes from two noise generally comes from two sources.

[0005.] Excessive vibration may lead to decreased HDD performance such as recoverable and non-recoverable write inhibits, increased seek times, and increased read and write access times. Excessive vibration or shock may also cause premature HDD failures that are not repairable. Examples include mechanically-damaged platters and read/write heads, mechanical wear on moving HDD components, and data error defects that cannot be corrected through the use of software tools. Also many HDDs in a confined space results in a substantial amount of heat generation. This heat must be dissipated in order to avoid over heating the HDDs and causing shortened product life.

[0006.] Currently, there is a void in the market as far as a complete solution that addresses vibration, thermal, and all other physical issues (mass, structure...) for hard drives. The proliferation of hard drives is growing rapidly. The typical CAGR (compound annual growth rate) for the various segments of the Storage Area Network (SAN) and Network Attached Storage (NAS) arenas are growing at a ~67% (typical). An increase in HDD performance will have a significant effect when considering the tremendous numbers of drives in operation.

[0007.] Much of the HDD industry continues to ignore the threat of damaging vibration as failure rates become exceedingly high and grasp at ineffective solutions. The nature of almost all problems is the need to resolve opposing constraints. The constraints invariably pull any of the possible solutions to a problem in different directions. Almost without fail, all solutions find that in improving one problem constraint that they diminish the solution from the aspect of one, or more, of the other imposed constraints. The position of making trade-offs and finding a "balance" of the capabilities needed to satisfy the need(s). An example of a potential solution that attempts to partially address the above-listed problems is included in US Patent Publication No. 2003/0222550 (US Application Serial No.; 10/417,111 filed April 17, 2003), invented by Boswell et. al and currently assigned to Xyratex Ltd. of Great Britain, which is hereby incorporated by reference for all purposes. However, the Boswell teachings do not fully address many of the relevant issues discussed above.

SUMMARY

[0008.] In view of the foregoing disadvantages in the known types of hard drive storage systems, the present invention provides a new solution wherein the same can be utilized for the storage of multiple hard drives.

[0009.] The present invention includes a packaging solution for hard disk drives that is a comprehensive embodiment promoting long term, reliable hard disk drive performance. The present invention not only completely addresses hard disk drive packaging requirements, but in particular embodiments provides a highly cost effective solution in the packaging and manufacture of hard disk drives in multiple markets. The solution provided by particular embodiments of the invention can be implemented for any number of hard drives, individually, or in any multi-disk configuration. The device embodying a preferred embodiment of the present invention for use in the hard disk drive market, will be referred to

as the Hard Drive Haven™ (also referred to as HDH™) in the present application. Although many solutions look to improve the drives performance, HDH™ instead offers to provide an environment that the drive will not need to improve, as the threats will be so greatly diminished.

[0010.] The present invention is generally applicable to hard disk drives in its preferred embodiments and more specifically it relates to an all encompassing solution for the storage of hard drives in a single or multi-hard drive environment. Although the invention primary envisioned for use with hard disk drives, the inventive concepts disclosed herein extend into many other industrial, commercial and personal applications in other alternate embodiments, without departing from the spirit and scope of the invention.

[0011.] The present invention takes advantage of the properties of carefully selected dampening materials by considering the polymer science, making the Hard Drive Haven™ an excellent HDD environment. The Hard Drive Haven™ provides an optimum HDD packaging for long term and reliable operation. As can be appreciated by those skilled in the art, the proper composition and configuration of materials used in the Hard Drive Haven™ is determined through analysis and resolution of vibration and resultant noise in the hard disk drives. Such analysis requires advanced techniques in modeling, analysis and testing, as well as consideration in the relevant materials technologies.\

[0012.] In a first and primary embodiment, the HDH™ is made of polymer which serves as a dampening device to minimize vibration, but also provides a thermal advantage, because it is a reduced-space or “footprint” solution, which also leaves as more open air maximizing air flow volume for cooling the HDDs.

[0013.] The hard disk drives (HDD) are mounted in various embodiments of the Hard Drive Haven™ in a wide range of devices and physical locations from personal computers to Storage Area Networks (SAN) to Network Attached

Storage (NAS) appliances, such as Redundant Array of Inexpensive Disks (RAID) arrays, Just a Box of Disks (JBODs), servers and a host of bulk data memory devices. HDD bay or chassis located within a system enclosure in a personal computer, in a JBOD, or any other location where the HDH™ could be easily installed.

[0014.] The present invention addresses many of the constraints involved in the packaging of HDDs, while simultaneously improving many performance indicators. The Haven offers a complete benign environment for a hard drive.

[0015.] The following list articulates a number of attributes, *inter alia*, that describe some of the feature and advantages of certain embodiment of the invention as embodied in the Hard Drive Haven™. All of the attributes listed apply to the performance, handling, distribution and long term reliability of hard drives. However, the list would be a very appealing list to many other applications for which the HDH™ could be easily adapted.

- **[0016.]** The invention provides for a low cost of manufacturing and low product cost (initial tooling cost has been calculated to be a one day payback for a \$50,000 tool based on extreme market demand and the piece part cost would be exceptionally low as compared to most existing alternatives – injection molding process is most likely, but not the only possibility).
- **[0017.]** Minimal part count, light weight and application flexible
- **[0018.]** Thermal Environment - minimal structure allowing maximum cross section for cooling air flow
- **[0019.]** Vibration & Shock Isolation and Damping

- **[0020.] Minimal Packaging Complexity** – with maximum hard drive density
- **[0021.] Acoustic Noise Reduction**
- **[0022.] High Mechanical Integrity**
- **[0023.] Structural Stability and Efficiency**
- **[0024.] Minimal Mass (Mass Efficiency)** –important in that HDDs are massive and the loads on data-com equipment racks will go up sharply with densely packaged hard drives, particularly if the packaging weight is not minimized.
- **[0025.] Reliable Interconnect (Hot Plug)** - Intelligent use of forces to create simple, highly reliable connector alignment, with no mechanical piece parts
- **[0026.] Improvements in electrostatic discharge**
- **[0027.] Ground isolation, advance pins on hot plug handle the discharge of any discharge.**
- **[0028.] Simple field replacement ability-** could even ship hard drives in OEM packaging for direct installation in the SAN and NAS.
- **[0029.] Simple Field Serviceability – Drive Level Replacement** (with no additional replacement components)

- **[0030.]** Designed for minimal field service
- **[0031.]** The industrial design is facilitated by existing faceplate design and snap fit features for assembly into the HDH™.

[0032.] The present invention provides the disk drive industry with an improved hard drive storage system that has many of the advantages of the HDH™ mentioned above but also include:

has no mechanical parts, and no electro-mechanics and provide exceptional performance.

allows the airflow passages are optimized.

provides an excellent thermal environment.

reduces vibration (external and drive to drive, RV), shock, and acoustic noise.

allows ease of distribution and replacement for hard drives in the field (shipped in original packaging).

structurally sound and minimizes mass.

provides electrostatic discharge and electrical grounding isolation for the HDDs.

it allows for highly reliable interconnect without the need for any mechanical alignment features.

low cost overall Solution for the packaging of hard drives.

completely snap fit assemble.

manage polymers in a vibration damping environment that has exceptional durability. This by using a variety of beam elements that work in unison to off load and not allow the over stressing of any other beams in the structure.

provide a common platform for mounting of hard drives to provide a predictable, benign and fully optimized solution to promote long term reliable hard drive performance.

standardize this platform in order to better compile consistent data of hard drive performance to continue to drive the technology to greater levels of capacity and performance.

provide the first complete solution for hard drives , from the manufacturer to end of life of each individual hard drive.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033.] The features and attendant advantages of the present invention will become fully appreciated as the same becomes better understood when considered in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the several views, and wherein. Please note that the drawings shown here are of the least complex beam structures, as this demonstrates the principle most clearly. There are a great range of beam cross sections and combinations that are under analysis and being shaped to optimize the Haven's performance. In later pages there will be drawings of a number of beam shapes and combinations rendered to demonstrate a small sample of the wide range of form factors that could and will be used to satisfy the needs of hard drives and other devices needing an environmental Haven.

[0034.] FIG. 1 is a perspective view of the present invention;

FIG. 2 is a front of the present invention showing all of the components;

FIG. 3 is a side view of the present invention;

FIG. 4 is a perspective view of the faceplate interfaces to the drive and the present invention;

FIG. 5 is a partially exploded view of the present invention;

FIG. 6 is a chart that illustrates the relationship to temperature and disk drive performance;

FIG. 7A is a representative example of the pre-stressed or load deflected compression polymer member.

FIG. 7B shows the results of 7A.

FIG. 8 illustrates the details present of the materials used in the present invention and their operation;

FIG. 9 illustrates shielding effectiveness;

FIG. 10 illustrates pressure drop;

FIG. 11 shows a plurality of HDH as they may be implemented;

FIG. 12 illustrates the advantages of using a polymer body in the housing of a hard disk drive;

FIG. 13 illustrates the detail of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0035.] Turning now descriptively to the drawings, in which like reference characters generally denote similar elements throughout the several views, the attached figures illustrate a hard drive mounting structure which is comprised of a polymer and which will be discussed more fully below.

[0036.] In the following disclosure, the preferred embodiment of the present invention will be referred to by one of its trade names the "Hard Drive Haven"™.

The Hard Drive Haven™ has a vibration dampening system that will damp vibration to and from other co-located hard drives and/or from external excitations from the local environment. The vibration that is created from other hard drives is referred to as RV, which stands for **Rotational Vibration**. Hard drive have rotating platters and this rotational energy can be transmitted from one hard drive to another and cause the receiving drive to experience a drop in performance. The hard drive Haven will utilize a very carefully structured series of beams that will combine in damping out vibration and acoustic noise over a wide range of frequencies and energy levels. The vibration dampening features will be molded from the structure that also serve as the support structure for the hard drives and as a stiffening system for the computer, server, storage array, digital recorder, desktop hard drive enclosure and many other possible applications. The focus herein is on hard drives but the application of this solution is extendable to any number of devices that are benefited by having vibration, shock and acoustic vibration damped from their operating environment.

[0037.] The present invention takes advantage of the fact that many Polymer composites have been found to have excellent damping properties that can be used to help control any unwanted vibrations produced by external dynamic loading. Moreover, the great flexibility available in composite structures through changing both materials and designs can be used to alter damping and resonance properties in desirable ways. See enclosed documents regarding these composites.

[0038.] Examples of appropriate polymers for computer applications include Delrin, Celanese, and Celstran. There are many polymers that offer the properties that will be required for the hard drive haven. Ultem, Valox and Noryl are three such polymers, as examples. Careful analysis, including finite element modeling will be necessary to ensure that the polymer(s) used can withstand the test of time and not yield as a result of creep and/or fatigue. In order to facilitate implementation of many possible embodiments of the invention, references

relating to the properties of polymers are incorporated herein. These publications include *The Handbook of Materials Science* by _____ (McGraw-Hill, 20__), and Additionally, the series by Bill Fry and published by the Society of Manufacturing Engineers *Speaking of Plastics Manufacturing* (1999), *Working with Acrylic*, *Working with Vinyl*, etc. may also be useful in determining the relevant properties of plastics and polymers in the manufacturing process of the present invention and is incorporated by reference.

[0039.] The illustration included herein reflect only a few of the possible beam structures that can be employed by the Hard Drive Haven™. The HDH (Hard Drive Haven) is designed to be capable of responding to a great number of inputs [??] and damping out the negative effects of _____, be having one beam support another and another support another, etc. With no beam beings tresses and or strained past the limits of the material used ensuring that the HDH prevails for the life of the product. The inventive suspension system holds the hard drive in a slot in the housing with the polymer springs. The polymer springs isolate the hard drive from the side panels and dampens the vibration produced by the hard drive itself as well as the vibrations transmitted through the sidewalls of the hard drive bay housing. The springs provide constraint and damping in an omni-directional manner, negating the adverse effects of vibration and acoustic noise from any conceivable source within the operating environment.

[0040.] Referring to FIG. 1, a primary embodiment of the invention is illustrated and includes a side panel 101 of a housing that incorporates an embodiment of the inventive hard drive suspension system. A second side panel is mounted in parallel 501 (as also shown in FIG. 5) with the illustrated panel so that both sides of the hard drives are in contact with the polymer springs. In the illustrated embodiment (which is only one configuration of many possible, single drive up to as many as required by the application), there are slots 106 for four hard drives which are separated by dividers 105. The inventive suspension system

comprises a polymer compression member which in this embodiment is an arched beam 102 that is incorporated into each of the dividers 105, contact the hard drives on the upper and lower surface of the devices. In addition there are compressive members 103 that contact the hard drives on the sides of the devices and compress as the drives are inserted into the hard drive haven. The beams are therefore in compression in both the vertical 102 and horizontal 103 axis of the hard drives and due to the nature of the forces that will be encountered and the nature of the polymers will act as omni-directional; reactions to all forces. The actual hard drive haven will employ beams of similar conceptual design, but may be very different in form factor as a result of detailed finite analysis. The greatest likelihood is that multiple beams of varying stiffness will be employed to react the multiplicity of stimuli the hard drives will encounter in operation. The diagrams enclosed are therefore intended to represent the concept and do so from a fundamental conceptual point of view. The multi stiffness beams will be designed to work in unison with each other being recruited as the load becomes more aggressive, for example in shock, but not allow the load to be too great on lesser strength beams before a stiffer load bearing beam is recruited.

[0041.] In a particular embodiment, the inventive suspension system also has springs or spring-like structures that engage the sides of the hard drive. These springs are similar to the springs in the dividers as described above, but are mounted in the center of the slots of the side panel. The side springs are made of a flexible polymer and have an arched structure that is attached at the ends of the beam to the side panel.

[0042.] The Hard Drive Haven™ also delivers a structurally efficient solution because of the strength to weight ratio of the materials chosen for use in the present invention. The molded plastics that are implemented in the present invention is greater than cold rolled steel, which is almost always used in such applications. For example, the mass of polymer (which one??)_____ is ~ 1/8 that of cold rolled steel. Increasing the strength to weight ratio is very important

in implementing particular embodiments of the present invention, as the mass of the systems including multiple hard drives is increasing, and the “floor loading” of data centers will not be able to accommodate bays that are filled with such mass dense packaging.

[0043.] In particular embodiments of the invention, the Hard Drive Haven™ also provides an assembly-conscious design that anticipates significantly reducing the effort required for manufacture. The Hard Drive Haven™ will “snap fit” into a sheet metal chassis. Reference 107 is a tongue (3 along the bottom of the bottom of the HDH and one at top center) that will fit into a slot in the sheet metal chassis (in the case where this is the final implementation). The top springs 102 will maintain the HDH in compression between the upper and lower sheet metal housing. The HDH also will include integral faceplates that provide a single snap-fit for the drive to the faceplate 403 and a single snap fit for the hard drive/faceplate combination in to the HDH 104/404. Therefore for applications (Enterprise or example) that HDH requires only three snap fit assembly steps for full HDH , hard Drive and faceplate assembly. With the use of metalized plastics that Electro-magnetic aspects of an enterprise solution can also be accommodated. It will often be necessary in enterprise applications to accommodate light pipes to provide optical feedback that the hard drives are operating correctly. These light pipes can easily be accommodated in the HDH side walls.

[0044.] FIG. 5 shows an example assembly of eight hard drives. The hard drives can be mounted right side up or upside down (as shown) 503. System architecture will dictate the most prudent choice in this case. The HDH can package the drives in very close proximity, but provide the necessary cooling air, structural integrity, vibration/shock/acoustic damping, ease of assembly, and a multitude of other benefits that are all delivered at an exceptionally low cost.

[0045.] At the present there are many companies packaging hard drives in closer and closer proximity with each other. There are metal boxes in metal boxes, in... \the preferred embodiment of the invention requires virtually no packaging, accepts the drive into the shelf with nothing required but a faceplate. Such a packaging system leaves all of the cross-sectional area between the drives free for delivering cooling air. This is important not only for the proper operation of the drives, but it is also very important for other system components, downstream of the drives, these components, often containing processors, can reject a great deal of heat. It is critical that drives be well cooled, and that the portion of system they reside in is not so densely packaged so as to slow the flow in the entire system. The HDH makes sure that as much of the critical airflow volume is available for the system components.

[0046.] The inventive suspension system of the present invention has numerous cutouts in the side panels. These "holes" are generally located next to the tops and bottoms of the hard drives allowing air to more freely flow over the upper and lower surfaces. The increased air flow, allows the inventive system to more easily cool the stacked hard drives through convection heat transfer.

[0047.] The thermal environment – it is a widely held opinion that the performance and length of time in which a hard drive will continue to function is inversely proportional to the temperature of the environment in which it operates. The actual degree to which the temperature is elevated is where the debate lies, but it is clear that the lower temperatures are better. With that said, one needs to understand the reality of where the hard drives will be deployed to realize that there is no good way to be certain of the ambient temperature that will be encountered and that this will be variable depending on what the final implementation is. Therefore, the drives will have to operate under a number of different environmental ambient temperature states. Since you cannot guarantee the temperature of the cooling air, then it is critical to guarantee that there is enough air to effectively remove the heat that the drive itself generates. I now

include the first graphic to assist in the description of the intellectual property described herein. Please note that the majority of the hard drive market is moving rapidly toward very dense packaging of hard drives to provide low cost data storage solutions. The increasing packaging density and the ever increasing capacity of the hard drive (Upwards of 500MB for one 3.5 inch HDD and climbing), making the thermal environment ever more aggressive for the hard drives and incrementally reducing the life expectancy of the hard drives. The need to get whatever little air possible to the drives and efficiently removing whatever heat possible is more critical than ever before. In order to help to demonstrate the manner in which the Hard Drive Haven addresses the thermal issues as well as many other aspects of hard drive packaging, the following diagram (Figure 1 - The Basic Form Fit & Function of the Hard Drive Haven) is submitted:

[0048.] Disk drives are complex electro-mechanical devices that can suffer performance degradation or failures due to a single event or a combination of events occurring over time. Environmental conditions that affect drive reliability include ambient temperature, cooling air flow rate, voltage, duty cycle, shock/vibration, and relative humidity. Fortunately, it is possible to predict certain types of failures by measuring environmental conditions. One of the worst enemies of hard disk drives is heat. Within a drive, the reliability of both the electronics and the mechanics (such as the spindle motor and actuator bearings) degrades as temperature rises. Running any disk drive at extreme temperatures for long periods of time is detrimental and can eventually lead to permanent data loss.

[0049.] FIG. 6 is The following paragraph, figure, paragraph comes from a white paper entitled “Hitachi's Drive Temperature Indicator Processor (Drive-TIP) helps ensure high drive reliability” by Gary Herbst, which is hereby incorporated by reference. To look at an example of the relationship between

temperature and hard drive (MTBF=Mean Time Before Failure; HDD = Hard Disk Drive).

[0050.] FIG. 6 shows the dramatic effect that temperature has on the overall reliability of a hard disk drive. Derivations from a nominal operating temperature (assumed to be maintained over the life of a drive) can result in a derivation from the nominal failure rate. As the temperature exceeds the recommended level, the failure rate increases two to three percent for every one degree rise above it. For example, a hard disk drive running for an extended period of time at five degrees above the recommended temperature can experience an increase in failure rate of 10 to 15 percent. Likewise, operating a drive below the recommended temperature can extend drive life.

[0051.] Normal mounting systems rigidly attach the hard drive to the slots or bays of a storage unit with screws and sheet metal slot components that physically contact the hard drive. Because of this rigid connection outside vibration is transmitted to the drive and the vibrations produced by the hard drive are transmitted to other hard drives in the housing exacerbating the vibration problem. In contrast to a rigid connection, the inventive hard drive suspension system isolates the hard drive from the frame with polymer springs which effectively dampen the transmitted vibrations. The polymer springs allow the hard drive to move in all three axes.

[0052.] In addition to vertical movement, the hard drive may also move from side to side or forward and backward in the slot. This freedom of movement results in reduced vibration transmitted to the hard drive from external sources. In addition to the mechanical spring properties, the polymer also has vibration absorption characteristics. In a normal spring, the physical energy resulting from compression is stored and released as the spring expands. In a preferred embodiment, the polymer springs are made of a material that absorbs some of the compression force and converts this energy into a different form. The energy may be converted into heat energy or alternatively, with a pizo-electric mechanism the physical energy can be converted into electrical energy.

[0053.] Polymers are effective in their response to a variety of vibration related issues, including: absorption of airborne sound; blocking airborne sound; damping, and vibration isolation. The HDH™ will employ polymers, composites and other appropriate materials in addressing all these issues, in a manner that is cost effective and delivers all requisite HDD packaging needs.

[0054.] Referring now to FIGS. 7A and B, a load deflection treatment and stiffening effect is shown. The stiffening effect results from the fact that the thin wall is stretched into tension as the plate deflects at P. The load deflection shown in FIG. 7A, illustrates this phenomenon with the results shown in FIG. 7B. For effective vibration control, it is often desirable to have a response that provides greater stiffness as the load increases. The behavior of membrane or shell stiffness, in polymers, provides this behavior without incremental cost. Simple it is a function of the geometry. With proper material selection, the cross section can be matched to the expected loading of the application. Diaphragm stiffening is a nonlinear increase in stiffness resulting from a change in curvature of a part. This effect is particularly pronounced when fixed boundary conditions are used.

[0055.] There are a variety of different materials that can be utilized depending on the devices form factors, level of damping required and the magnitude of the input forcing function. Diaphragm stiffening is a nonlinear increase in stiffness resulting from a change in curvature of a part. This effect is particularly pronounced when fixed boundary conditions are used.

FIG. 8 shows a number of conceptualizations of the types of features that might be used of the present invention.

[0056.] Table B, provides information on examples of polymers that might be employed for the Hard Drive Haven™, Demonstrating the properties that are required to deliver the performance necessary for the life of the systems in which the HDH™ will be employed. Data sheets of polymers that may be applicable to this invention, which are hereby incorporated by reference, and include some of the materials described below in Appendix A.

[0057.] Materials from Dupont include, DELRIN®... versatility in design, moulding and performance 6, HYTREL®... a thermoplastic and an elastomer all in one 8, ZYTEL® glass-reinforced... don't settle for ordinary glass-reinforced nylon... .. 20

[0058.] The appropriate materials appropriate for use in the present invention and available from GE include the various types of, Noryl, Ultem and Valox. A list of available materials from GE that may be appropriate for use in the present invention is available at the *GE POLYMERLAND-NORTH AMERICA* internet site.

[0059.] Other entities that manufacture the types of plastics and polymers include Parker-Hannefin, such as nickel-plated carbon-fiber, BASF, and others referenced in Appendix A.

[0060.] Simplified, lower mass and higher strength structures. Reduced packaging complexity, with increased reliability, serviceability, and ease of assemble. Ease of integration of industrial design features, ease of shipping replacements (could use the HDH™ or if not send drives in their original packaging and pop on a face plate at the site and slide into the HDH™).

[0061.] In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and to the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and

terminology employed herein are for the purpose of the description and should not be regarded as limiting.

[0062.]While the invention has been shown or described in only some of its forms, it should be apparent to those skilled in the art that it is not so limited, but is susceptible to various changes without departing from the cope of the invention. For example, the dampening materials may be formed from a thin film, sheet, molded or a combination thereof, and may be placed at a variety of interfaces to further reduce vibration and shock.

Claims

Having thus described my invention, I claim:

1. A unit for storing at least one hard disk drive, including:

two side panels mounted in parallel with each other, such that both sides of said at least one hard disk drive is in contact with a suspension system;

a set of slots for a plurality of hard drives separated by dividers, said number of slots corresponding to said number of disk drives;

said suspension system comprising a polymer compression member incorporated into each of said dividers;

wherein each of said polymer compression members contacts each of said disk drives at said upper and lower surfaces.

2. The unit for storing at least one hard disk drive as recited in claim 1, wherein said polymer compression member is an arched beam that is incorporated into each of said dividers.

3. The unit for storing at least one hard disk drive as recited in claim 1, wherein said polymer springs include Noryl.

4. The unit for storing at least one hard disk drive as recited in claim 1, wherein said polymer springs include Lexan.

5. The unit for storing at least one hard disk drive as recited in claim 1, wherein said polymer springs include Valox.
6. The unit for storing at least one hard disk drive as recited in claim 1, wherein said polymer springs include Delrin.
7. The unit for storing at least one hard disk drive as recited in claim 1, wherein said polymer springs include Hytrel.
8. The unit for storing at least one hard disk drive as recited in claim 1, wherein said polymer springs include Zytel.
9. The unit for storing at least one hard disk drive as recited in claim 1, wherein there is more than one set of said polymer springs said set of polymer springs made of at least two different materials.
10. The unit for storing at least one hard disk drive as recited in claim 9, wherein said at least one of said two different materials are chosen from among the group consisting of: Noryl, Lexan, Valox, Delrin, Hytrel, and Zytel.
11. The unit for storing at least one hard disk drive as recited in claim 1, wherein said compression member is configured as a coil.
12. The unit for storing at least one hard disk drive as recited in claim 1, wherein said compression member is configured two linearly adjacent arches.
13. The unit for storing at least one hard disk drive as recited in claim 1, wherein said compression member is configured as multiple arches.

- 14.** The unit for storing at least one hard disk drive as recited in claim 1,
wherein a horizontal compression member contacts the hard drives on the
upper and lower surface of the devices.
- 15.** The unit for storing at least one hard disk drive as recited in claim 1,
further comprising at least one complementary compressive member
contacting said at least one hard drive on the sides of the devices, such
that they engage the sides of the hard drive.
- 16.** The unit for storing at least one hard disk drive as recited in claim 15,
wherein said at least one complementary compressive member is
mounted in the center of the slots of said side panel.
- 17.** The unit for storing at least one hard disk drive as recited in claim 15
wherein said at least one complementary compression member is made of
a flexible polymer and have an arched structure that is attached at the
ends of the beam to the side panel.
- 18.** The unit for storing at least one hard disk drive as recited in claim 15,
wherein the compression of said at least one complementary compressive
member is perpendicular to the compression of said suspension system.
- 19.** The unit for storing at least one hard disk drive as recited in claim 15,
wherein said compression occurs as said drives are inserted into said slot.
- 20.** The unit for storing at least one hard disk drive as recited in claim 15,
wherein said compression is configured to occur in both the vertical and
horizontal axis of said hard drives.
- 21.** The unit for storing at least one hard disk drive as recited in claim 15,
wherein said polymers will act as omni-directional; reactions to all forces.

22. The unit for storing at least one hard disk drive as recited in claim 1,
wherein said multiple beams are configured to have varying stiffness.

23. A unit for storing at least one hard disk drive, including:

two side panels mounted in parallel with each other, such that both sides
of said at least one hard disk drive is in contact with a suspension system;

a set of slots for a plurality of hard drives separated by dividers, said
number of slots corresponding to said number of disk drives;

said suspension system comprising at set of polymer compression
members incorporated into each of said dividers;

wherein each of said polymer compression members contacts each of said
disk drives at said upper and lower surfaces; and

wherein said multiple compression members are configured to have
varying stiffness.

24. A method for reducing the vibration in a hard disk drive using the system
as recited in claim 23, including the step of configuring said multi-stiffness
beams to work in unison with at least another of one of said of beams.

25. The method as recited in claim 24, wherein said load becomes more
aggressive.

26. A system for housing a hard disk drive including:

a first and second side panel of a housing, said second side panel mounted in parallel with the said first side panel; wherein said first and second side panels having at least one slot for including at least one disk drive;

a first set of compressive members made of a polymer, and configured such that both the top and bottom of said at least one disk drive; and

a second set of compressive members made of a polymer, and configured such that both of said sides of said at least one disk drives are in contact with a set of polymer springs;

wherein said at least one disk drive is held firmly in place by said first and said second set of compressive members, whereby said rotational and external vibrations are reduced.

27. The system as recited in claim 26, further including a set of slots which are separated by dividers;

28. The system as recited in claim 27, wherein there are slots for four hard drives;

29. The system as recited in claim 28, wherein said first polymer compression member is an arched beam.

30. The system as recited in claim 29, wherein said multiple beams of varying stiffness will be employed.

31. The system as recited in claim 30, wherein said multi-stiffness beams are configured to work in unison.
32. The system as recited in claim 31, wherein said multi-stiffness beams working in unison resulting in each other being recruited as the load becomes more aggressive.
33. A system for controlling vibration in a hard disk drive including:
- a housing with two side walls and a slot for a hard disk drive, said side walls including a horizontal compression structure made of polymer means, said stiffness of said compression structure increased through
34. The system for controlling vibration in a hard disk drive as recited in claim 33 wherein said polymer means are selected from among the group consisting of: Noryl, Lexan, Valox, Delrin, Hytrel, and Zytel.
35. The system for controlling vibration in a hard disk drive as recited in claim 33, wherein the cross section of said compression member is matched to the expected loading of the application.
36. The system as recited in claim 33, wherein said stiffness resulting from a change in curvature of a part.
37. The system as recited in claim 33, wherein fixed boundary conditions are used.

ABSTRACT OF THE DISCLOSURE

A hard drive haven system for hard drives in a multiple environment that meets thermal, structural, interconnect ability, reliability, and mechanical integrity as is mandated for the life of a hard drive. The inventive device, as illustrated, is made from polymer materials that enhance vibration absorption, and acoustic noise. This inventive device will reduce the cost of metal solutions as well.

Figure 1 - Perspective View of the Hard Drive Haven

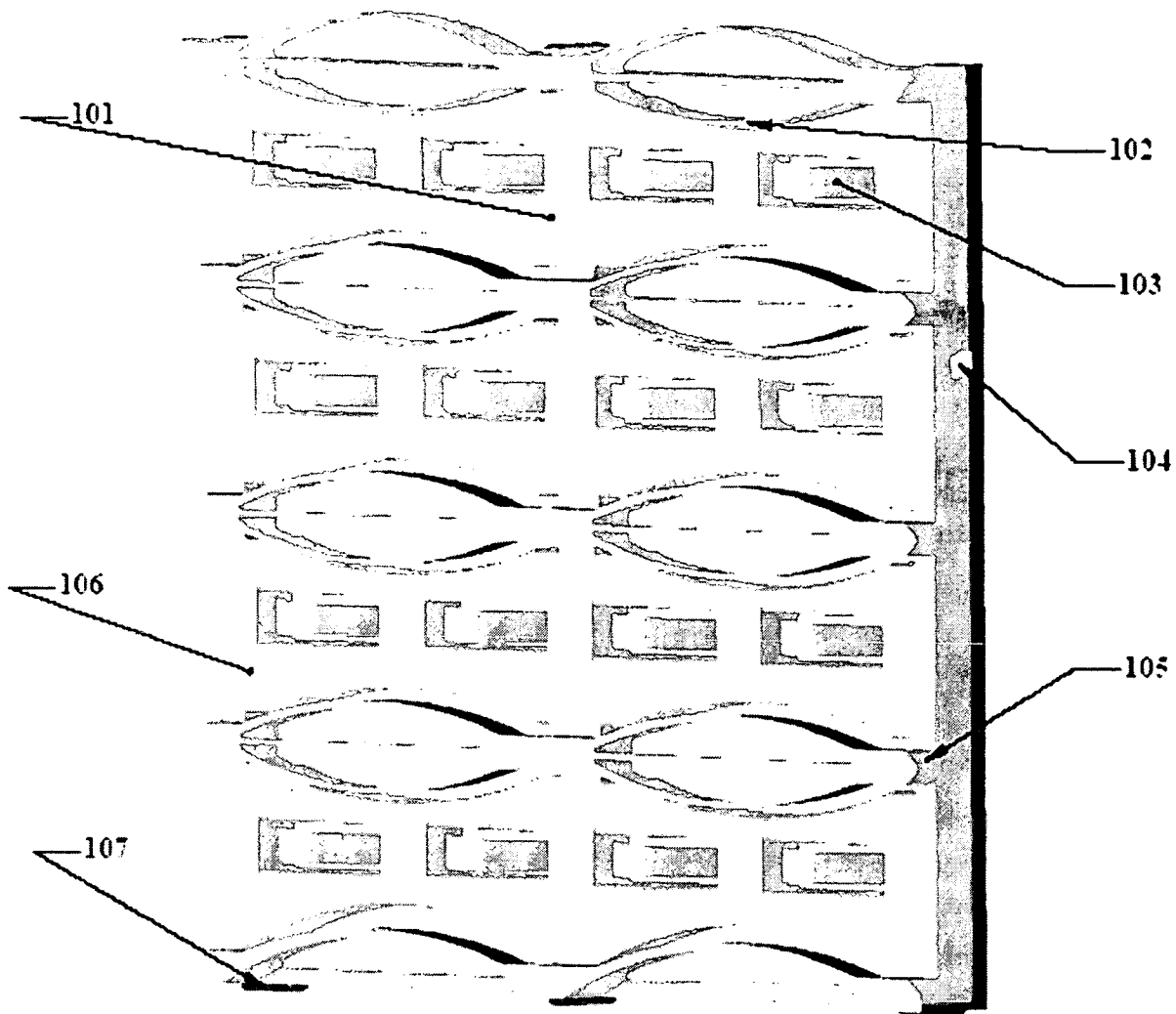
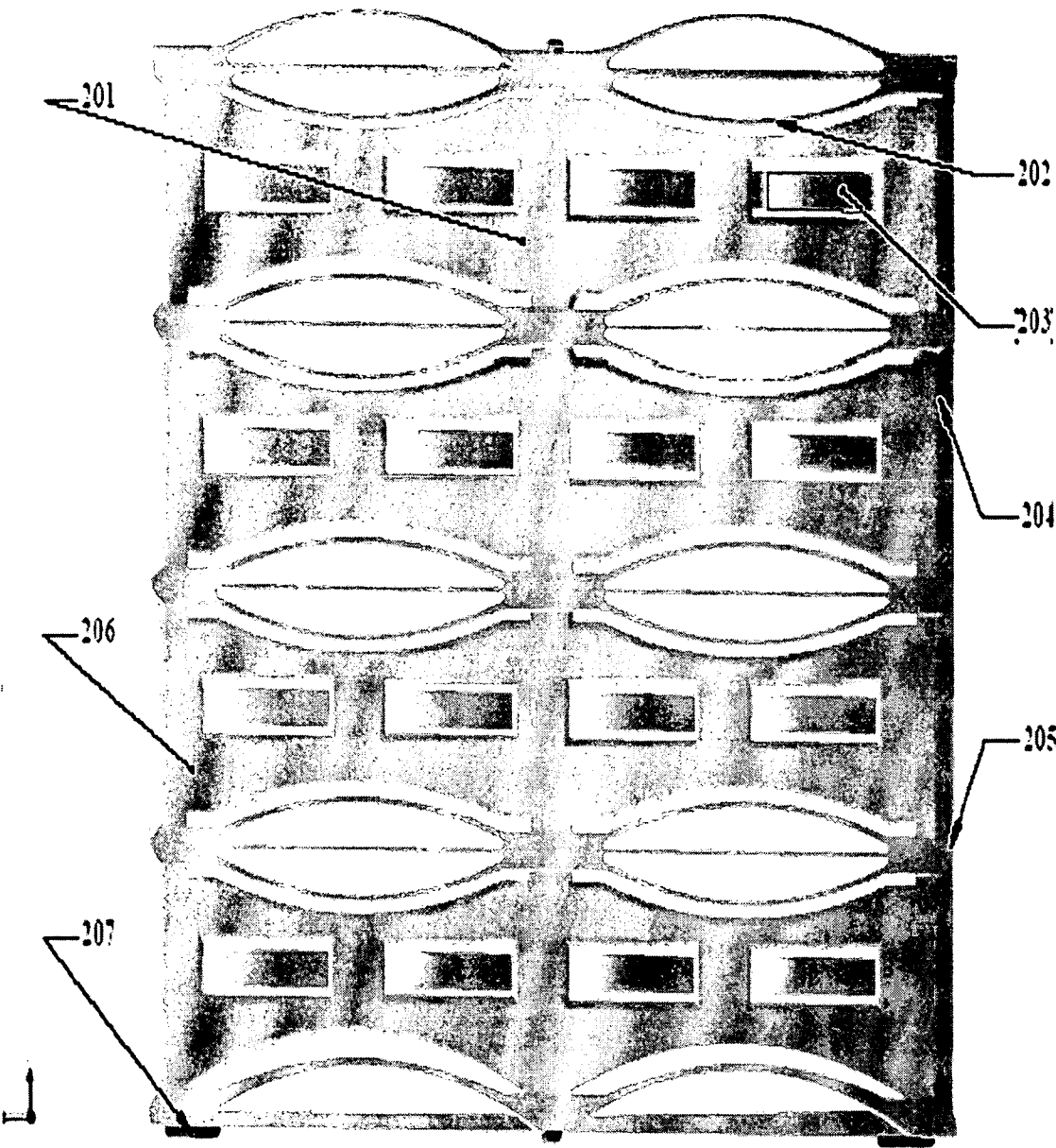


Fig. 1

Figure 2 -Front View of the Hard Drive Haven



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Fig. 2

Figure 3 - Side View of the Hard Drive Haven

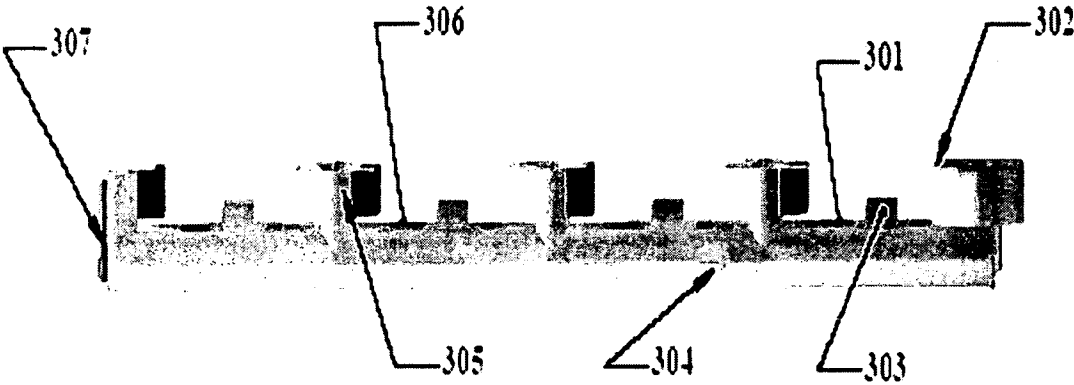
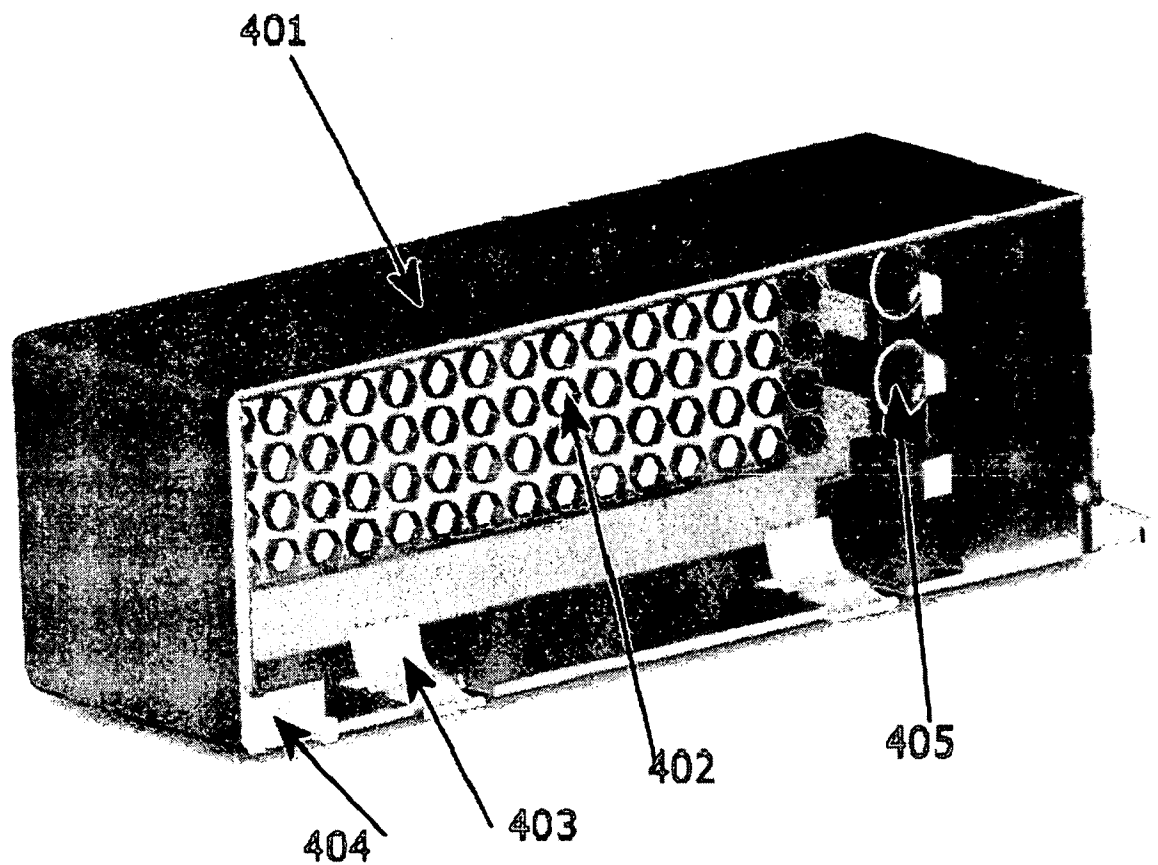


Fig. 3

Figure 4 - Perspective View of the Hard Drive Haven Faceplate



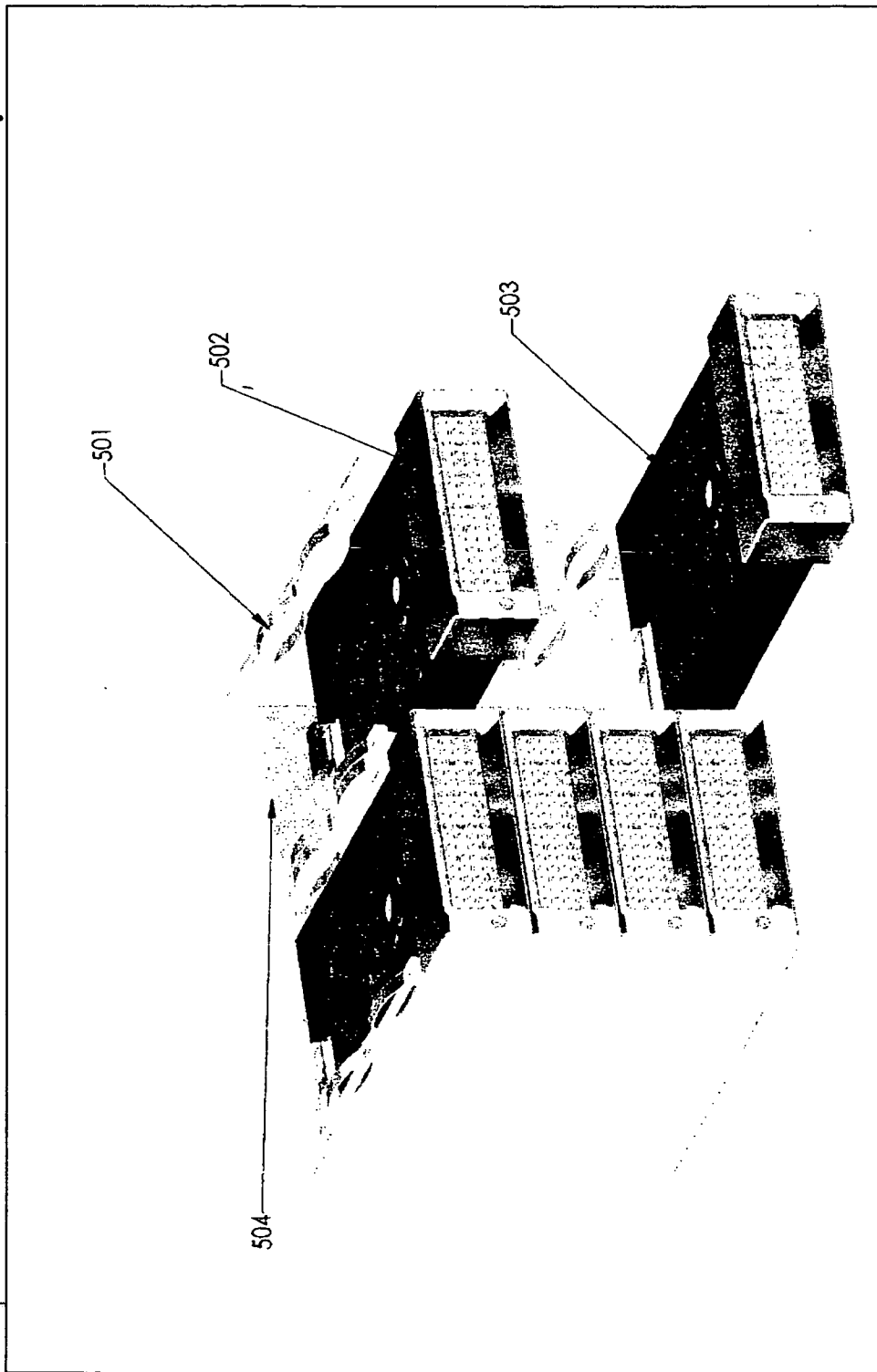
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Fig. 4

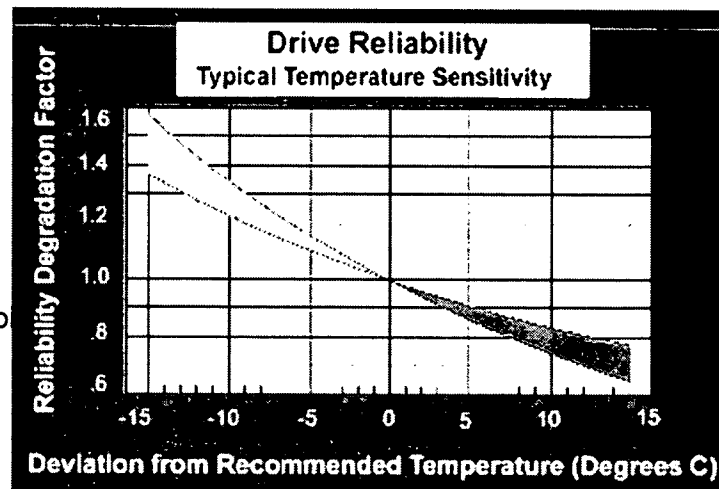
Figure 5 – An Example of a Hard Drive Haven Assembly



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Fig 5

Figure 6: Drive reliab



recommended levels

Figure 6: Drive reliability decreases significantly as temperature rises above recommended levels

Fig. 6

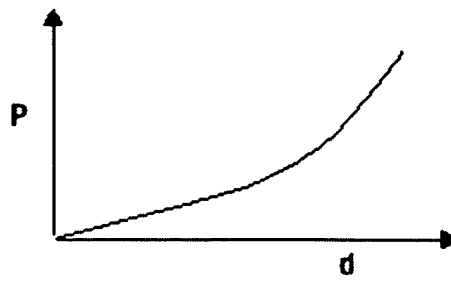
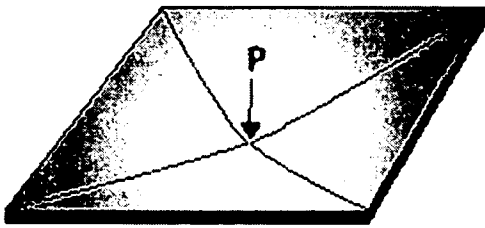


Fig. 7

#

Typical Shielding Effectiveness $3/16$ Cell

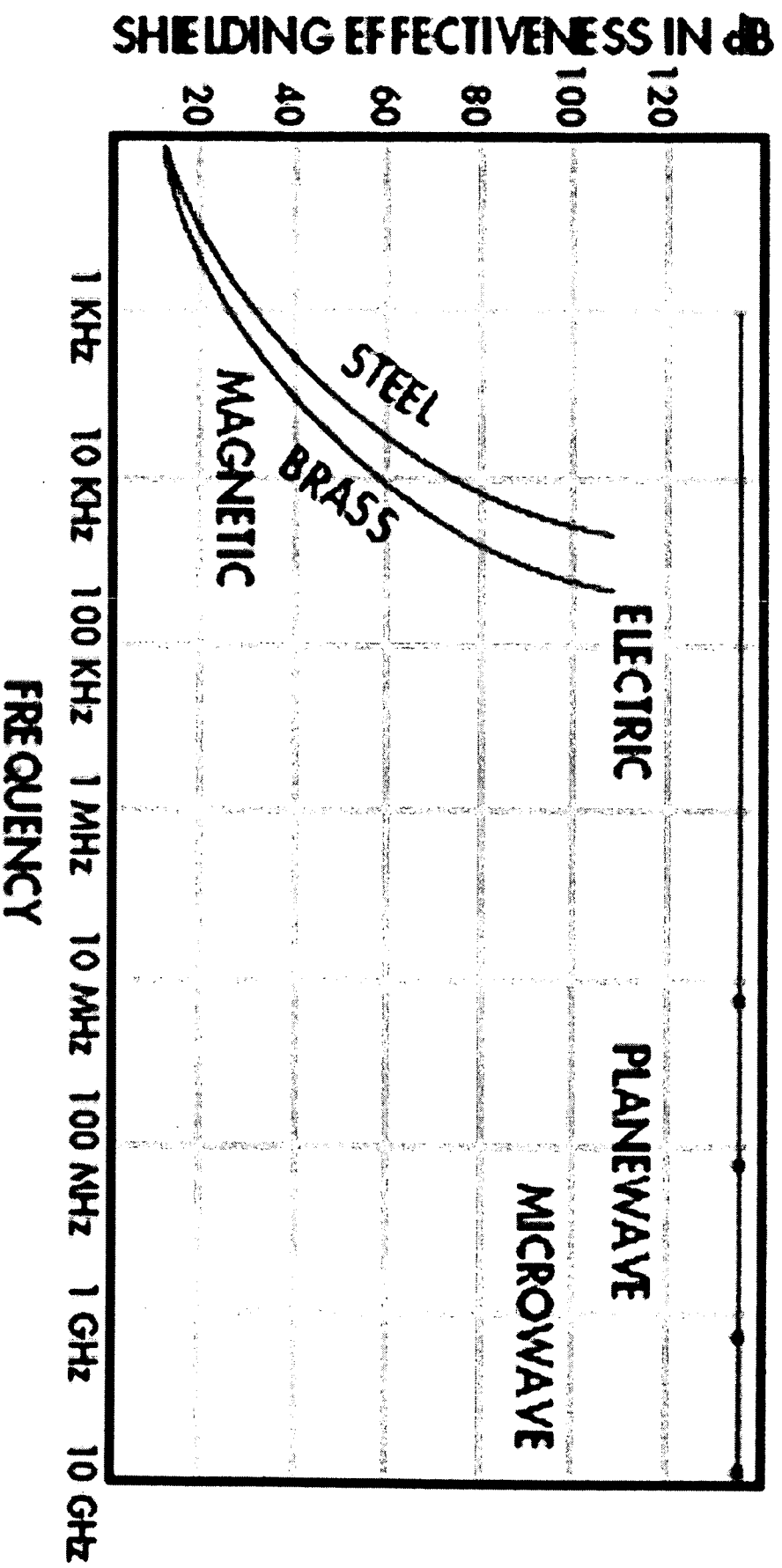
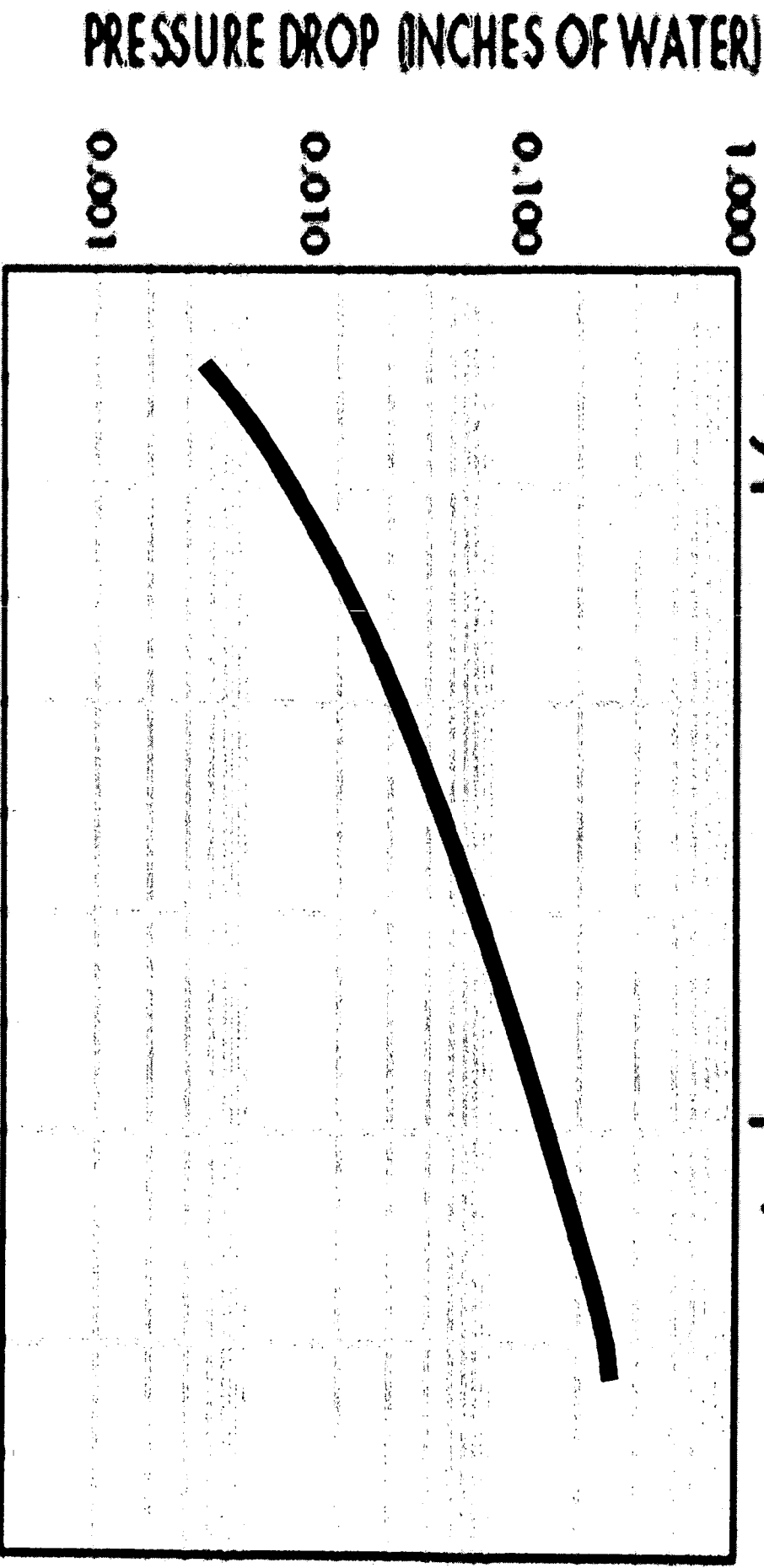


Fig 9

Typical Pressure Drop $\frac{3}{4}$ Cell



VELOCITY (FEET PER MINUTE)
Multiply by area to obtain CFM

Fig. 10

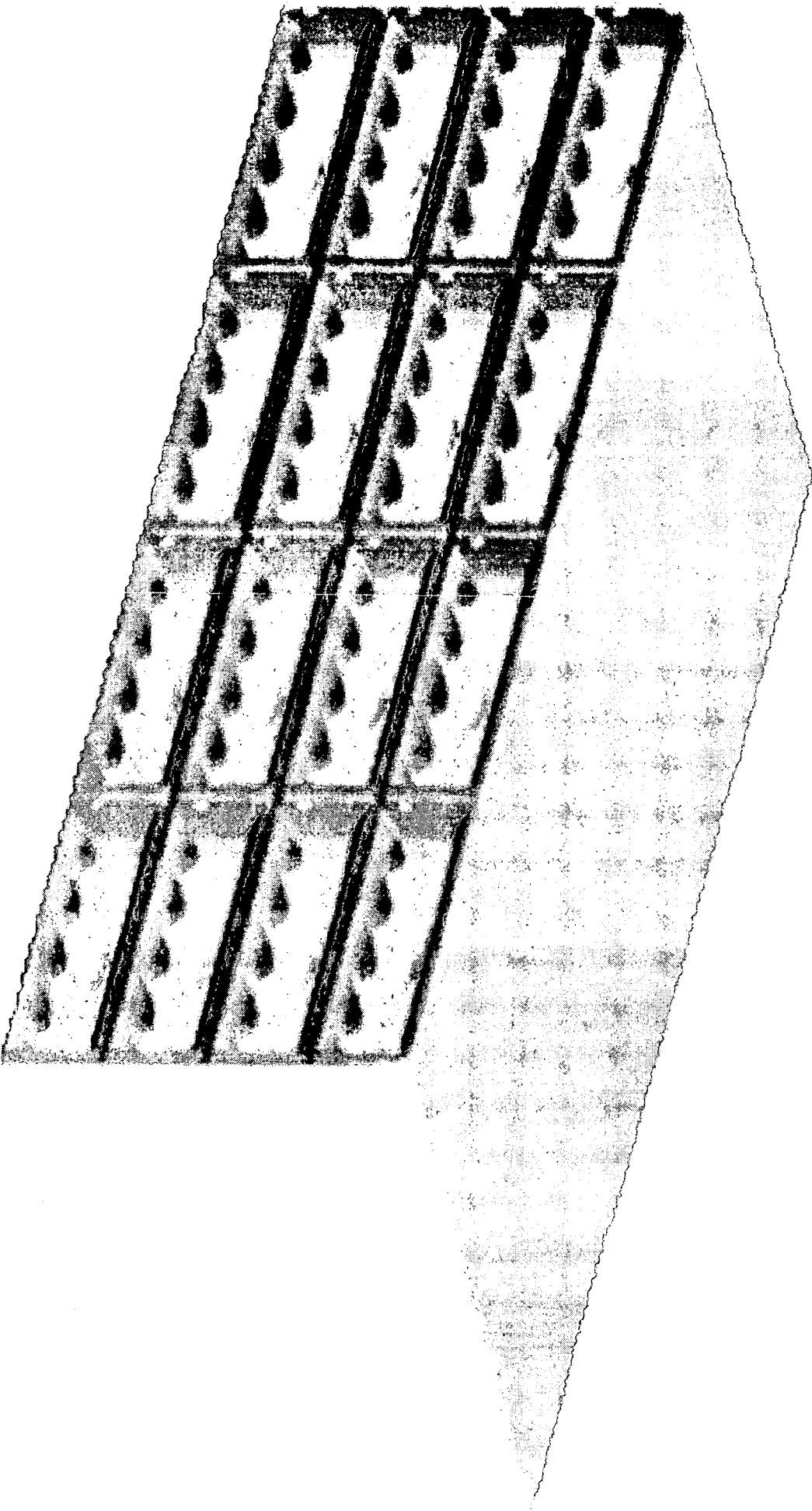
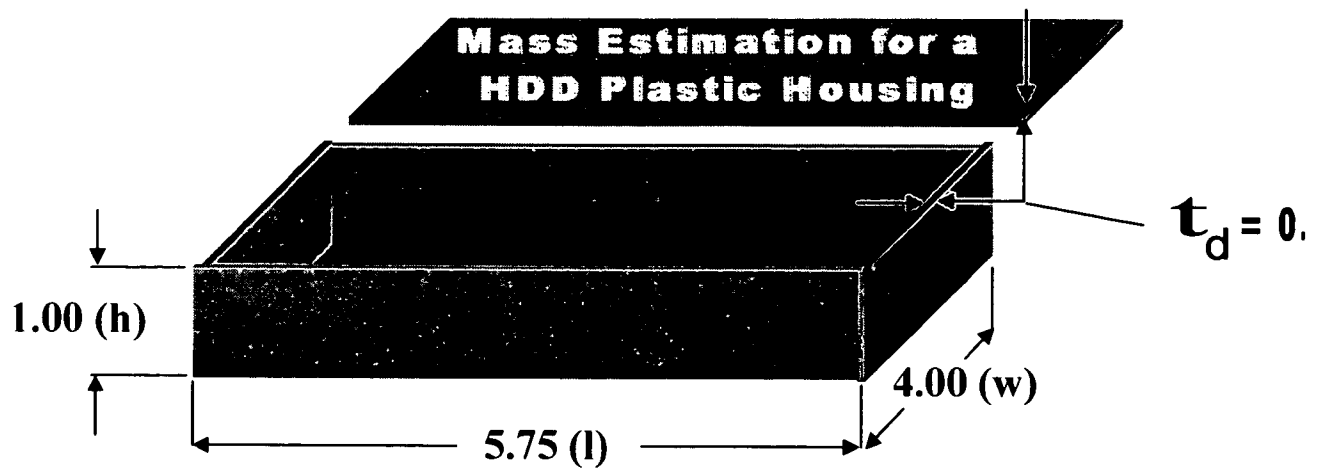


Fig. 11



To Calculate the volume of plastics, take the six sides of the box, using approximate dimensions of:

$$l \times w \times h = 5.75" \times 4.00" \times 1.00"$$

and further use the same wall thickness that is used in cast housings, assume drive wall thickness (t_d):

$$t_d = 0.075"$$

volume plastic (V_p) is then;

$$V_p = (2 \cdot (l \cdot w + w \cdot h + h \cdot l)) \cdot 0.075$$

$$= (2 \cdot (5.75 \cdot 4.00^\diamond + 4.00 \cdot 1.00 + 1.00 \cdot 5.75)) \cdot 0.075$$

$$V_p \approx 5 \text{ in}^3$$

♦ maybe only one $5.57 \cdot 4.00$ side if they maintain the sheet metal lid

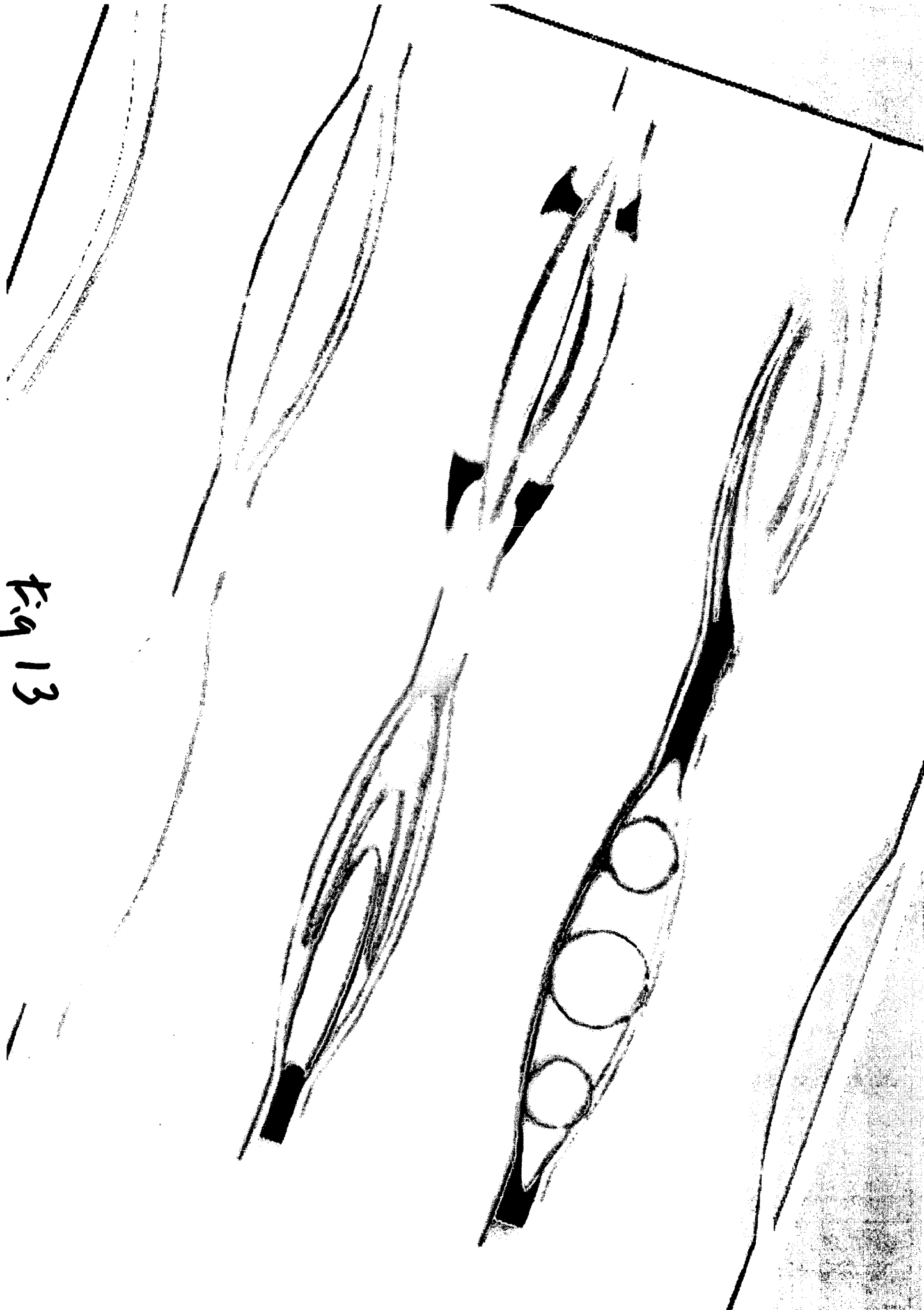
Based on current mass volume estimates the amount of plastics that would be need "per drive" is very near to the same thing as above.

Therefore assume V_p to be a constant, whether packaging in the Haven or making the hard drive bodies out of plastic.

Take the specific gravity of the plastic to be ~ 1.3 , therefore density would be approximately;

Fig. 12

Fig 13



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DECLARATION AND POWER OF ATTORNEY FOR ORIGINAL U.S. PATENT APPLICATION

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe that I am an original, first inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled: **SYSTEM AND METHOD FOR REDUCING VIBRATIONAL AND THERMAL PERTURBATION OF HARD DISK DRIVES USING ELASTIC POLYMER STRUCTURES**, the specification of which,

- (check one)
1. ☒ is attached hereto.
 2. ☐ was filed on as
U.S. Application Serial No. _____
and was amended on _____
 3. ☐ was filed on _____ as
International PCT Application Serial No. _____
and was amended on _____.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, CFR § 1.56.

I hereby claim foreign priority benefits under Title 35, United States code, § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have identified below, by checking the box, any foreign application of patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s): NONE

Priority Benefits
Claimed?

☐ Yes ☐ No

(Appl. No.) (Country) (Filing Date)

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below:

60/554,364 March 19, 2004
(Application Serial No.) (Filing Date)

(Application Serial No.) (Filing Date)

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

Prior U.S. Application(s)

(Application Serial No.)

(Filing Date)

(Status-patented, pending, abandoned)

(Application Serial No.)

(Filing Date)

(Status-patented, pending, abandoned)

And I hereby appoint: David Bogart Dort (Reg. No. 50,213), Brad R. Close (Registration under 10.9) and Tamiz Khan (Reg. No. 46,273) of the law firm of DORT CLOSE IP LAW GROUP PLLC, (Customer No. 42389) as my principal attorneys and/or agents to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Typewritten Full Name of

First Inventor: Paul Douglas Cochrane

Citizenship: Canadian

Inventor's Signature: _____

Date of Signature: _____

Residence: (City) Discovery Bay

(State/Country) CA

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